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Analysis of the sugar cane production efficiency using mechanized and semi-mechanized patterns in partners' sugar factories

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This study aims to analyze: the system of smallholder sugar cane farming with mechanized and semi-mechanized patterns; the level of efficiency and factors affecting the inefficiency of the cane of the people participating in mechanization and semi-mechanization; and the income from sugarcane farming with mechanized and semi-mechanized patterns. Data collection was carried out for all farmers using a survey method. Data were analyzed using the Cobb-Douglas production function (stochastic borders), then processed using Microsoft Excel and R software. The efficiency of mechanized and semi-mechanized cropping techniques was declared inefficient. Land area and the number of seeds cause economic inefficiency in mechanized and semi-mechanized non-ratoon cropping patterns. The same thing also applies to mechanized and semi-mechanized ratoon cropping patterns with variable land area. The highest income was obtained from mechanized sugarcane farming, while the lowest income was obtained from mechanized non-ratoon sugarcane farming. The highest production cost occurred in semi-mechanized non-squash sugarcane farming, and the lowest occurred in mechanized sugarcane farming. Furthermore, the highest net income was found in mechanized sugarcane farming and the lowest in semi-mechanized non-ratoon sugarcane farming. The R/C ratio > 1 indicates that all farming, both mechanized and semi-mechanized cropping patterns, provides benefits for farmers.
Keywords: Sugar cane, Efficiency, Mechanization, Semi mechanization, Production.

INTRODUCTION

The sugarcane plant (*Saccharum officinarum* L.) is a type of grass that is classified in the Graminae family and is known as a producer of sugar. Sugar is one of the basic needs and a relatively inexpensive source of calories for the community, so it is categorized as a strategic commodity. This plant only grows in the tropics; the soil needed to develop is alluvial, grumosol, latosol, and regusol, with an altitude of 0-600 meters above sea level (Chidoko and Chimway, 2011).
Since the time of Dutch colonial rule, Indonesia has had a sugar industry based on sugar cane. One of the oldest industries in the world is the sugar industry. This is evident from the history of the sugar industry, which dates back to the 13th century in Thailand, the 15th century in Brazil, and the 16th century, roughly, in Indonesia. In the 1930s, Indonesia's sugar industry was at its height, with 179 active sugar mills (PG), productivity of about 14.80%, and yields of 11%–13.80%. Up to three million tons of sugar were produced at its peak, and 2.40 million tons were exported. This success is attributed to the ease with which fertile land can be acquired, the affordability of labor, the importance of irrigation, and the discipline with which technology is applied (Tannady *et al.,* 2023).
A crucial good for the Indonesian economy is sugar. The development of the expansion of the sugar cane plantation area has been very slow, unlike other plantation commodities, especially oil palm, which has been running very fast. All parties must work together to make the most of available land and funding for the expansion of Indonesia's sugar industry. In addition to being viewed from the perspective of the supply of sugar required to achieve self-sufficiency, the growth of the sugar sector is strategic (Heryadi *et al*., 2023).
Sugar production activities cannot be separated from on-farm and off-farm activities. On-farm activities are all activities that are on the land, or it can be said to be cultivating sugar cane, and off-farm activities are activities outside the land, or it can be said to be downstream activities, namely processing sugar cane into sugar. Sugar cane plantations in Indonesia are mostly cultivated by the people as a raw material for making granulated sugar. Indonesia's sugarcane production (as measured in the form of crystalline sugar) itself in 2016

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reached 2 million metric tons, originating from 400 thousand ha of sugarcane harvested area. The consumption of sugar in Indonesia in the same year, based on the SUSENAS results, reached 7.5 kg/capita. This level of consumption is higher than the previous year, when it only reached 6.8 kg/capita (Mishra *et al.,* 2023).

The decline in sugar production and productivity in sugar cane cultivation is strongly influenced by plant factors, processing, and government policies. Several factors in the cultivation of sugar cane that are felt to be not optimal include cultivation practices, quality of planting material, plant health, and understanding of the role of varieties. Productivity is a synergy between the abilities of varieties and the management of their growing environment. In order for a variety to provide plant growth, it is necessary to understand the sugarcane management system (Fahriyah *et al*., 2018).

In order to assist the growth of the Indonesian sugar sector, the government has put in place a number of policies. Smallholder sugarcane plantations are typically more susceptible to changes and policies relating to output prices, sugarcane area, and production than PTPN area, production, and private plantations. Smallholder sugarcane plantation areas are also responsive to changes in input (fertilizer) prices and policies related to input prices (Amanullah *et al*., 2023).

Figure 1. Sugarcane Center in Indonesia
Source: google

A decrease in smallholder sugarcane production will have an impact on decreasing income for smallholder sugarcane farmers. Low-income results in limited capital owned by farmers. Increased farming costs often cause farmers to be unable to carry out the cultivation and production stages as well as use technology as they should. Whereas in sugarcane farming, the stages of cultivation and production, as well as the use of the right technology, are one way to increase high productivity so that maximum income is obtained (Andry *et al*., 2023).

Efforts made by the government to increase national sugar production increase the production of people's cane sugar because most of the national sugar, especially on the island of Java, is mostly produced from people's cane (Gunawan *et al*., 2019). The low productivity of the people's sugar cane reflects the low level of efficiency stemming from suboptimal cultivation in sugarcane farming activities. Increasing productivity is important considering that low productivity will in turn affect farmers' income. Low income is due to limited capital and land areas owned by farmers. Increased farming costs often cause farmers to be unable to carry out the stages of cultivation and production as well as use technology as they should (Nurprihatin *et al*., 2019). One way to overcome this is to develop partnerships between farmers and sugar mills through a mechanization program.

MATERIALS AND METHODS

Both primary data and secondary data were used in this study. A questionnaire is utilized as part of the research technique, which is survey research. Inferential statistics is a method of making statistical inferences based on samples taken from a population, and descriptive statistics is a method of data processing used in this study to collect and present a data set in order to provide useful information.

The process of organizing data sequences into a pattern, a category, and a description is known as data analysis. In this study, descriptive and inferential statistics were utilized to process the data. Inferential statistics are techniques for making inferences about the broader parent group, whereas descriptive statistics are techniques for gathering and presenting a data set in order to provide meaningful information. The collected data were then analyzed using computer software, namely Microsoft Excel and R Software, which were then presented and elaborated on to draw conclusions so that recommendations could be obtained from the research results.

RESULTS AND DISCUSSION

The conjecture results demonstrate that the input variables experience (X1), land area (X3), seeds (X4), herbicides (X6), and ZA fertilizer (X7) have a negative impact on farm production, while the input variables labor (X5), Phonska NPK fertilizer (X8), education (X2), and land area (X3) have a positive impact. The p-value for some of them, though, is bigger than 0.05 or 0.10, so not all of them have a discernible impact. Labor variables with a p-value of less than 0.05 are the variables that significantly affect the component of production. Farm production is significantly influenced by the labor component; as labor availability rises, so will farm output. In addition, ZA fertilizer (X7) and NPK Phonska fertilizer (X8) significantly affect alpha 0.1.

Table 1. Results of Cobb Douglas Function Estimation of Mechanized Non-Ratoon Planting Patterns.

Input Variables	Presumptive Parameters	t-value	VIF
Constant	-7.708190	-211.51	
Experience	-0.000317	-1.38	2.228
Education	0.000253	0.49	4.037
Land area	-0.000269	-1.18	2.201
Seed	-0.001710	-1.27	2.928
Labor	3.254496	376.74	2.206
Herbicide	-0.001505	-1.05	1.548
ZA Fertilizer	-0.001996	-2.16	3.869
Phonska NPK fertilizer	0.001656	2.06	4.761
R-Sq	0.999900		
Pr[F]	0.000000		

Source: Author (2023)

The conjecture's findings indicate that while experience (X1), land area (X3), labor (X5), and herbicides (X6) have positive effects on farm production, education (X2), seeds (X4), ZA fertilizer (X7), and Phonska fertilizer (X8) have negative effects. The labor variable is one of the eight input variables that significantly affects alpha 10%, and its p-value is less than the alpha value of 0.1, while the other variables have no significant impact.

According to the conjecture results, land area (X2) has a negative impact on farm production mechanization patterns, whereas fertilizer experience (X1), education (X2), labor (X5), herbicides (X6), ZA fertilizer (X4), and Phonska fertilizer (X5) have positive impacts. The p-value is less than the alpha value of 0.05 for the seven input factors that significantly affect alpha 5%, specifically the labor variable (X5), while other variables have no significant impact. The hypothesis results demonstrate that while other input variables have a beneficial impact on farm productivity, herbicides (X6) and NPK Phonska fertilizer (X8) have a negative impact on the production of semi-mechanized ratoon farming patterns. The seven input variables, there is no significant effect on alpha at 5% or 10%.

The automated non-ratoon cropping pattern demonstrates that there are no factors that significantly affect farm output. The variable land area (X3), with an elasticity value of 0.04, significantly affects the 10% alpha limit in the non-mechanized semi-mechanized cropping pattern. These findings suggest that in the semi-mechanized non-ratoon cropping pattern, the amount of land (X3) is still elastic. With an elasticity value of 0.25, labor also has a considerable impact on alpha 5%. This elasticity rating shows that a 10% more input will raise farmers' maximum output by 2.4% when other inputs stay the same. Variance and gamma parameter model of the effect of technical inefficiency on production function stochastic frontier cropping patterns of non-mechanized and semi-mechanized cropping patterns. The γ value of farmers on non-mechanized cropping patterns is less than 0.05. Statistically, the value obtained is not significant at α 5%. This shows that there is inefficiency in farming production in non-mechanized cropping patterns. Likewise, in the semi-mechanized non- ratoon cropping pattern, the γ value obtained was less than 5%. This shows that there is inefficiency in farming production in semi-mechanized, non-ratoon cropping patterns.

The mechanized ratoon cropping pattern demonstrates that the variable land area (X3), which has an elasticity of 0.04 at an alpha limit of 10%, has a considerable impact on farm production. The elasticity value indicates that increasing land area input by 10% with other variables fixed will increase farm production by 0.4%. These results indicate that the area of land (X3) is still elastic in the semi-mechanized ratoon cropping pattern. In addition, herbicides also have a significant effect on alpha 5%, with an elasticity of 0.25. The elasticity value indicates that increasing land area input by 10% with other variables fixed will increase farm production by 2.5%. There are no major variables in the semi-mechanized ratoon cropping pattern that affect the alpha limit of 5 or 10%.

Calculation of the economic efficiency of the use of production factors in farming on non-mechanized cropping patterns. The NPM Xi/Pxi value for the variable land area (X3) for farmers with a mechanized non- ratoon cropping pattern is less than one (0.001), which means that economically, the allocation of the use of leased land at the level of 5.25/ha is not efficient, so it is necessary to reduce the area of leased land. Likewise, the value of NPM Xi/Pxi on the seed variable (X4) and the Phonska fertilizer variable (X8) is also less than one, so the use of seeds at the level of 88/ha is not efficient, so it is necessary to reduce the number of seeds, as well as the use of Phonska fertilizer at the level of 665 kg/ha, which is not efficient and needs to be reduced. The workforce (X5) has an NPM Xi/Pxi value of more than one, so it has not yet reached economic efficiency, so additional workers can still be added. In the herbicide variable (X6), the NPM Xi/Pxi value is also greater than one, so the use of herbicides at 4.12 liters has not reached efficiency so that the use can be increased. In the ZA fertilizer variable (X7), the NPM Xi/Pxi is 1.36, the value is close enough to one so that the use of ZA fertilizer at 553 kg/ha is economically efficient enough.

Calculation of the economic efficiency of the use of farming production factors on semi-mechanized non- ratoon cropping patterns. The NPM Xi/Pxi value for the variable land area (X3) for farmers with non-mechanized cropping patterns is less than one, which means that economically, the allocation of the use of land area with rental status at the level of 3.67/ha is inefficient, so it is necessary to reduce land rent. Likewise, the value of NPM Xi/Pxi in the seed variable (X4) is also less than one, so the use of seed at the level of 91 Kw or Ha is not efficient, so it is necessary to reduce the number of seeds. On the labor variable, the value of NPM Xi/Pxi is more than one,

with a value of 8.3, so that it is not yet efficient and additional workers can be added. The use of herbicides has an NPM Xi/Pxi value of more than one, so at the herbicide level of 4.65 liters, it is not efficient, but it can still be added. For ZA fertilizer, the NPM Xi/Pxi value is 7,1, the value is more than one, so at a level of 615 kg/ha, the use of ZA fertilizer is not efficient, so to achieve economic efficiency, its use can still be added. Meanwhile, for Phonska fertilizer, the NPM Xi/Pxi value is close to one, so the use of Phonska fertilizer at a level of 693 kg/ha is quite efficient.

Calculation of the economic efficiency of the use of production factors in farming on mechanized ratoon cropping patterns. The NPM Xi/Pxi value for the variable land area (X3) for farmers with a mechanized non- ratoon cropping pattern is less than one, which means that economically, the allocation of the use of land area with rental status at the level of 5.25/ha is inefficient, so it is necessary to reduce land rent. while for the other variables labor, herbicides, ZA fertilizer, and Phonska fertilizer, the NPM Xi/Pxi value is more than one, so it is not economically efficient. At the labor level of 87, it is still not efficient, so additional workers can still be added. At the herbicide level of 4.19 liters, it is still not efficient, so it can be added. ZA fertilizer at the level of 553 kg/ha of ZA fertilizer use is not efficient, so to achieve economic efficiency, its use can still be added. Phonska fertilizer at the level of 665 kg/ha cannot be added efficiently.

Calculation of the economic efficiency of the use of farming production factors on semi-mechanized ratoon cropping patterns. The NPM Xi/Pxi value for the variable land area for farmers with a mechanized non- ratoon cropping pattern is less than one, which means that economically, the allocation of the use of land area with rental status at the level of 3.67/ha is not efficient, so it is necessary to reduce land rent. while for other variables such as labor, herbicides, ZA fertilizer, and phonska fertilizer, the NPM Xi/Pxi value is greater than one, so it is not economically efficient. At the labor level of 156, it is still not efficient, so additional workers can still be added. At the herbicide level of 4.7 liters, it is still not efficient, so it can be added. ZA fertilizer at the level of 611 kg/ha is not efficient, so to achieve economic efficiency, its use can still be added. Phonska fertilizer at the level of 664 kg/ha cannot be added efficiently.

Cultivation techniques carried out by farmers, including the use of production factors, affect the productivity of sugarcane plants because inefficiency is an internal constraint of the farmer. Despite the fact that agricultural mechanization is currently seen as essential to the realization of modern agriculture, it is important to understand that its successful implementation requires precise technology and administration, in addition to a number of other enabling variables. In order for mechanization to accomplish the desired results rather than the opposite, which increases the difficulties and responsibilities of production expenses for farmers.

The average cost of farming per hectare incurred by mechanized farmer respondents on non-ratoon planting status is 45 million, consisting of a fixed fee (57%) and a variable cost (43%). The biggest fixed costs incurred by the respondent farmers are land rental fees (52%), and the smallest irrigation fee. The largest variable cost element is labor, which is 11 million, and the smallest is the cost of buying herbicides. In the ratoon planting status, the cost mechanization pattern incurred by the respondent farmers is 40 million consisting of fixed costs (61%) and variable costs (39%). The biggest fixed cost incurred by the respondent farmers is the land rental fee of 24 million.

There are significant differences in farm production on non-ratoon and ratoon cropping patterns, both mechanized and semi-mechanized. The production yield on the ratoon cropping pattern was higher than that on the non-ratoon. Production yields with the semi-mechanized system were higher than those with the mechanized non- ratoon cropping pattern, while the mechanized system had a higher production than the semi-mechanized cropping pattern.

Sugarcane farming in the study area, both non-ratoon and ratoon planting status on mechanized and semi-mechanized patterns, is still financially feasible to cultivate because the RC value is > 1. Mechanized non-ratoon cropping pattern income per hectare per planting season averages six million. While the semi-mechanized non- ratoon planting pattern is three million/ha/year. The biggest income was obtained by respondents with the mechanized ratoon planting pattern, with an average income per hectare per season of 17 million followed by the semi-mechanized ratoon planting pattern, with an income of 14 million. The high and low incomes of sugar cane farming are influenced by the productivity of the cultivated plants. The highest productivity was obtained by respondents on the mechanized and semi-mechanized ratoon cropping patterns. The high productivity of the ratoon cropping pattern is influenced by the varieties of sugarcane planted.

The highest income or profit was obtained on the mechanized ratoon cropping pattern of IDR 17,682,603/ha/year, and the lowest income on semi-mechanized ratoon was IDR 3,2 mio/ha/year. When compared with the Regency UMK of IDR 1,8 mio it can be concluded that the income of sugar cane farming on a scale of < 1/ha is still below the UMK. According to the results of the interviews, the average land area owned by the respondent farmer is 3.5/ha for the semi-mechanized pattern and 6 ha for the mechanized pattern. This means that if sugarcane farming is done on a scale of land area of at least 3.5 ha on land status, the income of sugarcane farmers is higher than the UMK.

***Conclusions*:** The sugarcane farming pattern consists of cultivating non- ratoon sugarcane (plant cane) and ratoon with a mechanized system with a special credit facility and semi-mechanized without a credit facility, also known as free

people's sugar cane. The non- ratoon sugarcane cultivation pattern is a sugarcane cultivation pattern using seeds, and the ratoon pattern is sugarcane cultivation without seeds or plants that grow after the plants are cut down. Labor, ZA fertilizer, and phonska fertilizer are the three factors that significantly affect farm yield in non-mechanized cropping patterns. The labor variable significantly increases farm output in the semi-mechanized non-ratoon cropping pattern. The production yields of mechanized ratoon cropping patterns are significantly influenced by labor as well, but semi-mechanized ratoon cropping patterns are not significantly influenced by any variables. The efficiency of the mechanized non- ratoon, semi-mechanized non- ratoon, and mechanized and semi-mechanized ratoon was stated in the inefficient condition. Economic efficiency in the use of production factors for non-mechanized and non-mechanized cropping patterns with semi-mechanized land area and seed variables is not efficient, so it needs reduction, and other variables are not efficient, so it needs addition. In the mechanized ratoon and semi-mechanized ratoon cropping patterns, the variable area of land is not efficient, so it is necessary to reduce it, while the other variables are not efficient, so they can be added.

The average income from mechanized non- ratoon sugarcane farming is 52 million/ha, and the total costs incurred are 45 mio net income per ha with an average of 6 mio/ha. While the status of semi-mechanized non-ratoon sugarcane average revenue is 54 mio, the costs incurred are an average of 50 mio/ha with an average income of three millions The average income of mechanized sugar cane farming is 58 mio and the total costs incurred average 40 mio with an income of 17 mio/ha. Meanwhile, the income from semi-mechanized sugar cane farming is 56 mio; total production costs are 42 mio; and the average net income is 14 mio. Sugarcane farming in the study area, with both mechanized and semi-mechanized cropping patterns, is still financially feasible to cultivate because the RC value is >1. The highest income or profit is obtained on mechanized ratoon cropping patterns, and the lowest income is obtained on mechanized non-ratoon. Different cropping patterns produce different production averages. The ratoon pattern has a higher production yield than the non-mechanized pattern with both mechanized and non-mechanized systems. The mechanized system has a production yield that is less than semi-mechanized on the non-mechanized pattern, but on the ratoon pattern, the mechanized yield is higher than the semi-mechanized one.

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